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SCIENCE

FRIDAY, DECEMBER 30, 1910

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
THE MAKING OF A DARWIN¹

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I MAY take my text from a recent remark of Henry Fairfield Osborn to the effect that a Darwin could not be produced in the American university of to-day. This raises a number of questions, some of them unanswerable, but all of them worthy of the attention of scientific men interested in the continuance of a race of investigators.

As a starting point, I may quote Professor Osborn's words in full:

If "the poet is born, not made," the man of science is surely both born and made. Rare as was Darwin's genius, it was not more rare than the wonderful succession of outward events which shaped his life. It was true in 1817, as to-day, that few teachers teach and few educators educate. It is true that those were the dull days of classical and mathematical drill. Yet look at the roster of Cambridge and see the men it produced. From Darwin's regular college work he may have gained but little, yet he was all the while enjoying an exceptional training. Step by step he was made a strong man by a mental guidance which is without parallel, by the precepts and example of his father, for whom he held the greatest reverence, by his reading the poetry of Shakspeare, Wordsworth, Coleridge and Milton, and the scientific prose of Paley, Herschel and Humboldt, by the subtle scholarly influences of old Cambridge, by the scientific inspirations and advice of Henslow, by the masterful inductive influence of the geologist Lyell, and by the great nature panorama of the voyage of the *Beagle*.

The college mates of Darwin saw more truly than he himself what the old university was doing for him. Professor Poulton, of Oxford, believes that the kind of life which so favored Darwin's mind has largely disappeared in English universities, especially under the sharp sys-

¹ Retiring president's address before the American Association for the Advancement of Science, Minneapolis, Minn., December 27, 1910.

tem of competitive examinations. Yet this is still more truly the atmosphere of old Cambridge to-day than of any of our American institutions. It would be an interesting subject to debate whether we could nurture such a man; whether Darwin, were he entered at a Columbia, a Harvard or a Princeton, could develop mentally as Charles Darwin did at Cambridge in 1817. I believe that conditions for the favorable nurture of such a mind are not with us. They are repose, time for continuous thought, respect for the man of brains and of individuality, and of such peculiar tastes as Darwin displayed in his avidity for collecting beetles, freedom from mental convention, general sympathy for nature, and above all order in the world of ideas. If the genial mind can not find the kindred mind, it can not develop. Many American school and college men are laughed out of the finest promptings of their natures. In short, I believe our intellectual environment would be distinctly against a young Darwin of to-day.

These words of Osborn hint at certain weaknesses in our American educational system to which I shall refer later on. Meanwhile, I do not think that it is the whole truth, nor wholly the truth. If a Darwin were to be laughed out of his career, the event would have occurred in the English secondary school, where he was in fact nicknamed "Gas" on account of his interest in chemistry. And it is certainly not true that in the old Cambridge, or the new Cambridge, there is as high a valuation of unexpected originality as the suppositious young Darwin would find to-day in America.

I think that the elements which make up a Darwin can be reduced to three, whereof the first far overtops the others, the heredity of great genius being far more rare than one would infer from Osborn's words, and far more difficult to mar or discourage.

What, then, are the elements that we unite to make a great investigator, not of Darwin's class, let us say, for that comes only with many centuries, but a naturalist not unworthy to come in as a foot-note to a

page on Darwinism? The fundamental elements, as I take it, are these three: First, the original material, to which we may look to heredity alone; second, meeting nature at first hand and meeting her early and persistently; third, the personal inspiration and enthusiasm derived from some great teacher. In Darwin's case, the raw material was of the highest order, the best which amphimixis ever put together. This material no university could spoil, though Cambridge and Edinburgh confessedly tried their best. Beetles, race-horses, flowers and trees, contact with nature—these kept up an enthusiasm promoted rather than checked by the hopeless dreariness of his university exercises. These gave the second element, and the third came from the privilege of the young Darwin to be "the man who walked with Henslow," and later with Sedgwick also.

In the American universities, heredity plays her part; her limitations, whatever they may be, are racial, and our stock is good. Nature is close at hand, closer than in the old world, and whosoever is really filled with zeal to know her has not far to go. Agassiz remained in America because in America he was nearer to his studies than he could be in Europe. Here "nature was rich, while tools and workmen were few and traditions none." All this our American universities offer in abundance. The final question is, then, that of personality, and the question I would raise is whether in accumulating tools and traditions even as in Europe, we are not failing in this regard. Are we not losing sight of the *man*, of the thing above all others which goes to the shaping of a great naturalist or a great scholar in any field? We may say that the machinery of our universities is developed not for the shaping of a Darwin, but for the moulding of very commonplace models. But so it is every-

where. Paulsen could never conceive that any of the great scholars of England should be professors in an English university. The work of the university, with its gowns and hoods, its convocations and degrees, its taking seriously the state-governed church and the hereditary aristocracy, seems so alien to the life of the great scholar that one can not conceive his taking part in them. And yet great scholars have done just this. They have developed in just this atmosphere, drinking from the real fountains of learning hidden within the university, and not from the drippings of the gargoyles with which medievalism has adorned its exterior.

In like fashion, we could not conceive of the young Darwin, in a claw-hammer coat in the afternoon defending his one major and two minors, with a thesis which no one will ever read, on a topic leading up a blind alley, as a doctor in any German university. But even this, or much worse or more incongruous, might happen to a Darwin or a Huxley, or a Lyell or a Gray, or a Helmholtz, an Agassiz or a Gegenbaur, were such to grow up into the universities of to-day. External count for little, and all these things are external. The man, the teacher and the contact with nature—these are the only realities. The beginning is in the man, his ability, his “fanaticism for veracity,” and his persistence in the work. The university can not make the man. It can not wholly shut him away from objective truth, even if it tries desperately to do so, and its principal influence is found in the degree to which it grants the inspiration of personality.

The reading of good books can not be regarded as an element peculiar to any sort of university training. A good mind seeks good books and finds them. Shakspeare, Coleridge and Lyell were just as accessible to me or to you as they were to Darwin.

They are just as accessible to anybody anywhere. Time to read them is not even essential. One secret of greatness is to find time for everything in proportion to its worth to us. A further advantage is ours in this generation. We have the “Origin of Species” and the whole array of fructifying literature arising from this virile stem.

The only possible element in which the American university could fail is that of the influence of personality. Can it be that this influence is wanting? Do our men no longer “walk with Henslow,” as once they walked with Gray and Silliman and Agassiz?

Do our men go to the university for the school's sake and not for the men who are in it? Is it true that as our universities grow in numbers and wealth, their force as personal centers or builders of schools of thought are declining? To some extent this is certainly true. Once when a young naturalist went in search of training and inspiration, he went to Agassiz. He did not go to Harvard. He scarcely thought of Harvard in this connection. Agassiz was the university, not Harvard. The botanist went to Gray. He did not go to Harvard. Later the chemist went to Remsen, the physiologist to Martin, the anatomist to Wall, the morphologist to Brooks. That these four men happened to be together at Johns Hopkins was only an incident. The student went out to find the man, and he would have followed this man around the world, if he had changed from one to another institution.

I saw the other day a paper of an irate German morphologist who in attacking a certain idea as to the origin of fishes' arms and ours, denounced “die ganze Gegenbaurische Schule,” who followed Gegenbaur in his interpretation of this problem. Never mind the contention. The point is

that there is a Gegenbaur School of Morphology. This school was not the university, but Gegenbaur himself. We ought to have more such schools in America, schools of advanced thinkers gathered around a man they love, and from whose methods and enthusiasm the young men go away to be centers of like enthusiasm for others. I believe that our system of university fellowships is a powerful agency in breaking up this condition. If, by chance, it were possible for us to produce a Darwin, the raw material furnished, it would be a difficult task if a fellowship of \$500 has drawn him to the laboratory of some lesser plodder, preventing him forever from being "the man that walked with Henslow." The fellowship system keeps our graduate courses running regardless of whether these courses have anything to give. So long as our fellows are hired to take degrees, then sent out to starve as instructors, so long will we find our output unworthy of our apparent advantages. And in our sober moments we will say with Osborn, we do not see how an American university could produce a Darwin. And at the same time, professors in universities in other lands will admit that the machinery for mediocrity offers little promise to the great. Jacques Loeb tells the story of a young man who applied through him for a fellowship in physiology at Chicago. His admiration for Loeb's wonderful genius as an experimenter and as an original worker on the borderland of life and matter led him to wish to work with Loeb above all other things. Loeb wrote back that he had resigned his chair in the University of Chicago to go to the University of California. Then, said the candidate, "will you kindly turn over my application for a fellowship to your successor at the University of Chicago?" This single case is typical of the attitude into which our fellowship system

as it is now administered throws the young diggers who arise in our various colleges. The embryo professor asks for his training not the man of genius who will make him over after his kind, but the university which will pay his expenses while he goes on to qualify for an instructor's position. By this and other means we are filling the ranks of our teaching force, not with enthusiasts either for teaching or for research, but with docile, mechanical men, who do their work fairly, but with few touches of the individuality without which no Darwins nor Darwinoids can ever be produced. It is a proverb at Harvard, I am told, that "the worm will turn, and he turns into a graduate student."

Thirty-eight years ago it was my fortune as a beginner in science to attend the meeting of this association at Dubuque. The very contact with men of science, which this meeting gave, was a wealth of inspiration. To hear these men speak, to touch their hands, to meet them on the street, to ride with them to the fossil-bearing rocks, or the flower-carpeted prairie, for the moment at least to be counted of their number, all these meant wonderful things.

Of these men, let me speak primarily of the students of natural history, for then, and even yet, I know little of anything else. They were naturalists "of the old school," these workers of the early seventies. Louis Agassiz, dean of them all, was not at Dubuque, but I came to know him very soon after. There was Asa Gray. I heard at Dubuque some Harvard man say, "There goes Asa Gray. If he should say black was white, I should see it looking whitish." There was Shaler, the many-sided, every side altogether charming; and Spencer F. Baird, the father of cooperative science, the science at the Capitol at Washington. There was Fred Putnam, the ever-present veteran, a veteran even in his

youth. There was Joe Le Conte, ever clear-headed and ever lovable. There was Newberry and Leslie and Gill and Allen and Swallow and Leidy and Calvin and Marsh and Coues, Wilder with his shark brains, and Scudder with his butterflies, and I know not what others, the great names of thirty years ago, names which we honor to-day. These men of the old school were lovers of nature. They knew nature, as a whole, rather than as a fragment or a succession of fragments. They were not made in Germany nor anywhere else, and their work was done because they loved it, because the impulse within would not let them do otherwise than work, and their training, partly their own, partly responsible to their source of inspiration, was made to fit their own purposes. If these men went to Germany, as many of them did, it was for inspiration, not for direction; not to sit through lectures, not to dig in some far-off corner of knowledge, not to stand through a doctor's examination in a dress coat with a major and two minors, not to be encouraged *magna cum laude* to undertake a scientific career. The career was fixed by heredity and early environment. Nothing could head them off and they took orders from no one as to what they should do, or what they should reach as conclusions. They did not work for a career—many of them found none—but for the love of work. They were filled with a rampant exuberant individuality which took them wherever they pleased to go. They followed no set fashions in biology. Such methods as they had were their own, wrought out by their own strength. They were dependent on neither libraries nor equipment, though they struggled for both. Not facilities for work, but endeavor to work, if need be without facilities, gave them strength, and their strength was as the strength of ten.

For this reason, each typical man of this sort had Darwin walking with him. He became the center of a school of natural history, a rallying point for younger men who sought from him, not his methods, nor his conclusions, but his zeal, his enthusiasm, his "fanaticism for veracity," his love for nature, using that hackneyed phrase in the sense in which men spoke it when the phrase was new.

Students of Agassiz, notably Scudder, Lyman, Shaler and Wilder, have told us what all this meant, where "the best friend that ever student had" was their living and moving teacher. The friendship implied in this, his worthiest epitaph, rested not on material aid, but on recognition of "the hunger and thirst that only the destitute student knows," the craving to know what really is, which outranks all other human cravings.

Marcou tells us the story of the wonderful work done in the little college of Neuchâtel, without money, materials or prestige, investigating, writing, printing, engraving, publishing, all in one busy hive at a thousand dollars a year, when the greatest of teachers had youth, enthusiasm, love of nature and love of man as his chief or only equipment. This story was repeated, with variations, at Cambridge, and with other variations by Agassiz's disciples throughout the length and breadth of America.

I heard Agassiz say once, "I lived for four years in Munich under Dr. Döllinger's roof and my scientific training goes back to him and to him alone." Later in America, he dedicated his contribution to the "memory of Ignatius Döllinger, who first taught me to trace the development of animals."

This suggests the thought of the heredity in science so characteristic of the old school. From Döllinger, Agassiz was descended.

From Agassiz, all of the naturalists of the old school of to-day, all the teachers and investigators who have reached the sixty-year mark or are soon to reach it. These men, from Joseph Le Conte and David A. Wells, of his first class, through Shaler, Wilder, Putnam, Alexander Agassiz, Hartt, Baird, Walcott, Whitman, Brooks, Snow, Lyman, Clark, William James, Faxon, Fewkes, Garman, down to Minot and myself, the two youngest of the lot, as I remember; Minot venerable already, according to the Boston press.

It is a characteristic of the men of the old school that they formed schools, that they were centers of attraction to the like-minded wherever these might be. There were no fellowships in those days whereby men are hired to work under men they do not care for and along lines which lead not to the truth they love, but to a degree and a career. We speak sometimes of the Agassiz school of naturalists, the Gray school of botanists, as in Germany "*die ganze Gegenbaurische Schule*" of anatomy, "*die Haeckelsche Schule*" of biology. These may be terms of praise or of opprobrium, according to the degree of one's sympathy with that school and its purposes.

To belong to a school in this sense is to share the inspiration of its leader. The Gray school of botanists no longer places the buttercup or the virgin's bower at the head of the list of plants, as a typical flower. Gray did this, but this is not an essential in honoring Gray. They begin at the bottom, Darwin-fashion, and the honor of the end of the list is given to the specialized asters and mints, or the still wider wandering orchids, the most eccentric, the most remotely modified, no longer to the typical, the conventionally simple. In this there is a tacit assumption that Gray would have done the same had he possessed the knowledge which is now the common

property of his students. Probably he would, but that matters nothing, for each one follows his own individuality.

The characteristic of the Agassiz school was the early and utter discarding of the elaborate zoological philosophy which the master had built up. The school went over bodily to the side of Darwin, not because Darwin had convinced them by his arguments, but because their own work in whatever field led them to the same conclusions. No one who studied species in detail could look an animal in the face and believe in the theory of special creation. The same lesson came up from every hand, and we should not have been true to the doctrines of the master if we had refused faith to our own experience. When the Museum of Comparative Zoology was finished, Haeckel is reported to have said, perhaps in envy, perhaps in jest, that "the output of any scientific establishment is in inverse ratio to the completeness of its equipment." In other words, the more men have to do with the less they would do.

Statistics show that in this paradox there is at least a grain of truth, and this grain of truth stands at the base of my own misgivings. With the scantiest of equipment, much of our greatest work has been done. It is said that Joseph Leidy's array of microscopes and knives cost less than a hundred dollars. The "*Poissons Fossiles*" was written when its author lived from hand to mouth in the Latin Quarter of Paris, copying "on the backs of old letters and on odd scraps of paper the books he needed, but which he could not buy." Since Haeckel said the words I have quoted, and he tells me that I said them, facilities for biological work have multiplied a thousand fold. Every German university, Jena with the rest, and most American universities as well, have a far greater equipment than the Museum

of Comparative Anatomy had forty years ago. Victor Mayer is reported to have said that the equipment of every chemical laboratory should be burned once in ten years. This is necessary that the chemical investigator should be a free man, not hampered by his outgrown environment. In like vein, Eigenmann has said that when an investigator dies, all his material should be burned with him. These should be his creation, and he should create nothing which he can not use. These could be useful to none other, except as material for the history of science. Therefore, too much may be worse than too little. The struggle for the necessary is often the making of the investigator. If he gets what he wants without a struggle, he may not know what to do with it.

For facilities do not create. The men who have honored their universities owe very little to the facilities their universities have offered them. Men are born, not made. They are strengthened by endeavor, not by facilities. *Facilis descensus*. It is easy to slide in the direction of least resistance. That direction is not upward. It is easy to be swamped by material for work, or by the multiplicity of cares, or by the multiplication of opportunities. I may be pardoned for another personal allusion. I have spent the best portion of my life in the service of science, but for the most part not in direct service. I have tried to help others to opportunities I could not use myself. I have been glad to do this, because that which I might have done has been far more than balanced by the help I have been able to give to others.

But it is not clear that this greater help has led to greater achievement. I can not find that the output bears any direct relation to the means for producing it. The man who is born to zeal for experiment or observation can not be put down. He is

always at it. Somewhere or somehow he will come to his own. No man ever adds much to the sum of human knowledge because the road is made easy for him. Leisure, salary, libraries, apparatus, problems, appreciation, none of these will make an investigator out of a man who is willing to be anything else. There is human nature among scientific men, and human nature is prone to follow the lines of least resistance. It takes originality, enthusiasm, abounding life, to turn any man from what is easily known to that which is knowable only through the sweat of the intellect. Of all the men I have tried to train in biology, those five I regard as ablest because of their contributions to science have been greatest, were brought up out of doors or within bare walls in which books, specimens and equipment were furnished from the scant salary. A struggling teacher, a very young teacher at that, at \$1,800 per year, and ten per cent. of this for a biological library, is not a condition to attract advanced students to-day, but so far as my own experience has gone, I have never known stronger students than those who came to me to be trained under these pinching conditions. To-day these conditions are adjusted to the promotion of the docile student rather than the man of original force. He goes not to the man but the university. He finds work in biology, no longer a bit of green sod under the blue sky shut off by conventional and ugly hedges, and therefore to be acquired at any cost. It is a park, open on every side to anybody. Or, dropping the poor metaphor, he finds his favorite work not a single hard-won opportunity in a mass of required language and mathematics. He finds the university like a great hotel with a menu so varied that he is lost in the abundance. His favorite zoology or botany is not taught by a man. It is divided into a dozen branches

each taught by an instructor who is a cog-wheel in the machine. The master under whom he would seek inspiration is busy with the planning of additional cog wheels or the oiling of the machinery. Or, more often, there is no master teacher at all. The machinery is there and at his hand. He has but to touch the button and he has alcohol, formal, xylol or Canada balsam, whatever he needs for his present work. Every usable drug and every usable instrument is on tap; all we need, degrees and all, are made for us in Germany. Another button will bring him all the books of all the ages, all the records of past experience, carrying knowledge far ahead of his present requirements, usually beyond his possible acquirements. The touch of personality, the dash of heredity, is lost. Worse than all this, for the student who is worth while will orient himself even among the most elaborate appliances and the most varied concourse of elective, is the fact that he is set to acquire training without enthusiasm. Sooner or later he receives a fellowship in some institution which is not the one to which he wishes to go. Virtually, he finds himself hired to work in some particular place, not under the man of all men he has chosen to know. He is given some petty problem; it seems petty to him and to others. He takes this as his major, with two convenient minors, and at last he is turned out with his degree to find his own life if he can. His next experience is to starve, and he is not so well fitted for this as he would have been had he begun it sooner. If he finds himself among facilities for work, he will starve physically only. If he marries, he starves in good company, but more rapidly and under greater stress. If chance throws him into a college without facilities, he will starve mentally also. In any case, he will lament the fact that the university has given him

so much material help, so little personal inspiration and at the end values its product so low, that with all the demands of scholarship and scholarly living his pay is less than that of the bricklayer or the hack driver. For he has attained a degree of scholarship without a corresponding degree of compelling force. His education has not given him mastery of men, because its direction has not been adequately his own. It is always the struggle which gives strength. Learning or polish may be gained in other ways, but without self-directed effort there is not much intellectual virility. Good pay, like some other good things, comes to the man who compels it. To make oneself indispensable, real, forceful, with a many-sided interest in men as well as in specialized learning is the remedy for low salaries. As college men we get all that we are worth on the average. Our fault is that we are in the average. We need more individuality.

In so far as the universities can remedy this, it would lie in the encouragement of men to take their advanced work in actual centers of inspiration. No one university has many such. Let the fellowships lead men to the few. Or let them be traveling fellowships available at the best centers of inspiration in this or any other country. Or, if the choice among departments be too delicate a matter for university officials to undertake, let the distribution of fellowships be confined to the men who already are on the ground. These men, in one way or another, have shown their confidence, have chosen their master. If the university wishes now to smooth their path to success, it would give pecuniary assistance without hiring them to go where they do not wish to go. There is no nobler ambition for a great investigator than to hope from a school of science to continue his own kind, by his own method, his own inspira-

tion, the contagion of his own love of knowledge. In no way can this be done save by letting like come to like, by opening the way from his own kind to find the way to their master. In this our present fellowship system is failing, and this failure is showing itself in the cheapening of virility and the cheapening of originality among our doctors of philosophy, as compared with our young workers of a generation ago.

An eminent teacher of physics said lately:

The numbers of doctor's degrees in physics bear no relation to the eminence of the professors who grant them. They depend solely on the number of fellowships offered, on the number of assistantships available. In the institution which has conferred the greatest number in recent years, almost every one of these is drawn by the stipend offered; scarcely one by the unquestioned greatness of the leading professor.

The primary fault seems to be in our conception of research, which tends to point in the direction of pedantry rather than that of scholarship. Not all professors have this tendency; only those who are neither great scholars nor great teachers. It is, or ought to be, a maxim of education that advanced work in any subject has greater value to the student, as discipline or as information, than elementary work. Thoroughness and breadth of knowledge give strength of mind and better perspective. They give above all courage and enthusiasm. With each year, up to a certain point, our universities carry their studies further toward these ends, and the student responds to each demand made on his intelligence and his enthusiasm.

Then research begins, and here the teacher, as a matter of duty, transforms himself into the pedant. Instead of a closer contact with nature and her problems, the student is side-tracked into some corner in which numerical exactness is possible, even

though no possible truth can be drawn from the multiplicity of facts which may be gathered.

This sort of research, recently satirized by Professor Grant Showerman, in the *Atlantic Monthly*, is not advanced work at all. It may be most elementary. The student of the grammar school can count the pebbles in a gravel bank to see what percentage of them lie with the longest axis horizontal as easily as the master can do it. That is not research in geology, however great the pains which may be taken to ensure accuracy. The student may learn something. All contact with gravel teaches something of the nature of rocks, as all reading of Plautus teaches something of poetry; all contact with realities gives some reality as a result. Yet there is no result involved in the case above indicated, in the investigation itself. We know that if flat stones are free to fall, the longest axis will approach horizontality, and that is the end of the matter.

Mr. Showerman's suggested comparison of the "prefixes in P. to be found in Plautus," "the terminations in T. of Terence" and "the sundry suffixes in S.," is scarcely an exaggeration of the kind of work assigned to many of our research students. Such work is in itself absolutely elementary. It teaches patience and perhaps exactness, although, where the student finds that error is just as good as truth in the final round-up, he is likely to lose some of "the fanaticism for veracity" which is the central element in the zealous comradery of the extension of human knowledge. So long as the "new work" on which our doctors of philosophy address themselves is found in material rejected by scholars because a study of it can not possibly lead anywhere, so long will these doctors be neither teachers nor enthusiasts. They will justify the clever sneer as to the turn-

ing worm and the graduate student. Elementary facts about raw material are not the advancement of knowledge. They are killing to those who have a capacity for something better. The listing of "Terence's terminations in T." is a type of work which at the best bears the same relation to research that forge-work bears to engineering. It is worth while to the engineer to know what it is like and to be able to handle a hammer if need be. Moreover, a hammered-out horse-shoe is an actual reality. But to make a horse-shoe, even one of a form never seen before, is not the final thesis for which the engineer enters the university.

Much of the graduate work in non-mathematical subjects receives an appearance of accuracy from the use of statistics, or other forms of mathematics. This seems to make the results "scientific." Mathematics is a science only when its subject-matter is science—when it deals with results of human experience. At other times, it is simply a method—a form of logic. A mathematical enumeration, or even a formula, does not give exactness where it did not exist before.

The statistical enumeration of the "prefixes in P.," or the pebbles in the bank, is held to give the method of research. It teaches patience and accuracy, two fundamental virtues in the progress of science. Patience, perhaps, if the student persists to the bitter end. Accuracy certainly not. Sooner or later the student will discover that to multiply by ten one of his columns of figures or to divide another by five will have no effect on his final conclusion, for there isn't going to be any conclusion. He will then learn to supplement his tables by the quicker and more satisfactory method of guess work. He turns from the methods of pedantry to the method of journalism. At the best, he will find that the less labori-

ous methods known as qualitative have the advantage over quantitative methods, where matters of quantity have no real significance.

No one should begrudge any amount of time or strength or patience spent on a real problem. In that regard, Darwin's attitude towards the greatest of biological problems is a model for all time. But we should believe that there is a problem, and that our facts point towards the truth in regard to it. A fact alone is not a truth, and ten thousand facts may be of no more importance. A horse-shoe is not an achievement. Still less are ten thousand horse-shoes. "Facts are stupid things," Agassiz used to say, "unless brought into connection by some general law." In other words, facts signify nothing, except as the raw material of truth.

A graduate student of an honored philologist in a great university lately explained her graduate work to me. A chapter in Luther's bible was assigned to her, another to each of her fellows. This was copied in longhand, and after it, all the variant German versions of the same chapter. Her work was to indicate all the differences involved. There may have been something behind it all. The professor may have had in mind a great law of variance, a *Lautverschiebung* or *Entwicklung* of pious phraseology. But no glimpse of this law ever came to the student. More likely, the professor was at his wits' end to find some task in German which had never been accomplished before, and which had never before occurred to any German taskmaster. No wonder the doctor's degree is no guarantee of skill as a teacher! Among the first essentials of a teacher are clearness of vision and enthusiasm for the work. This is not cultivated by these methods. It is not even "made in Germany." The "law of time relations of iron and sul-

phuric acid" may be developed in a year's work by dropping a thousand weighed shingle nails into a thousand test-tubes of sulphuric acid, each having the amount requisite to turn the whole into an iron sulphate. The length of the period before each shingle nail disappears and that before the resultant liquid becomes clear can be measured. It may even be proved that the cleaner the nail, the more quickly it dissolves. But all this is not chemical research. It gives no wider grasp on the marvelous processes of chemical reaction, and no greater enthusiasm for chemical work, nor grasp on chemical teaching.

If the counting in Plautus of the prefixes in P. is a type of the only sort of research that the classical knowledges permit, then let them go without research. Let them fall back on the charms of Latin verse, the surprises of Latin wit, the matchless power of description of which the Greek language is capable, and the monumental splendor of the oldest of the storytellers, who brought even the gods into his service. Let literature be literature, and science science, and enthusiasm will precede and follow any real advance in knowledge. Let the student be free to learn and not to grind. Let him go with the masters of his own free will, not as he is hired by the pedants. As a final result, we shall have again schools of thought and action in America, and the doctor's degree will not be a hindrance in the profession of university teaching.

When our graduate work is really advanced work, under men who know the universe in the large as well as in the small, its great movements as well as its forgotten dust heaps, we shall have our American schools of science, and the Darwins will again "walk with Henslow," over fields as green as were ever those of Cambridge-shire.

With the failure of the enthusiasm of the teacher, we have a lowering of ideals on the part of students. They come too often to look for science as a career rather than as an opportunity to do that which in all the world they would rather do, that which they would die rather than leave undone. Too often, in the words of John Cassin, "they look upon science as a milk cow rather than as a transcendent goddess."

The advent of the elective system, thirty years ago, bore a wonderful fruitage. Men, soul-weary of drill, turned to inspiration. Teachers who loved their work were met by students who loved it. The students of science thirty years ago came to it to escape from Latin and calculus with the eagerness of colts brought from the barn to a spring pasture. In regions of eternal spring, these colts do not show this vernal eagerness. Now that science is as much a matter of course as anything else, there is not this feeling of release; and the feeling that one to whom the secrets of the woods and hills, the story of the sea and the rocks, have been made known, belongs to a chosen class, disappears when these matters are made open to every one. Scientific knowledge as the result of continued endeavor and of persistent longing is more appreciated than when it comes as an open elective to all who have completed English 3 and Mathematics 5.

In one of the poems of James Whitcomb Riley, this sentence is expressed:

Let's go a visiting back to Grigsby's Station,
Back where we used to live, so happy and so poor.

"So happy and so poor" the American college once was, that the student, the teacher and nature were all together, all hand in hand. It was this which made at Munich the "Little Academy" concerning which Agassiz once spoke so eloquently. It was the contrast with greatness in the most simple surroundings that gave the

school at Penikese its unique position. As to this school, I once used these words:

With all appreciation of the rich streams which in late years have come to us from many sources, and especially from the deep insight and resolute truthfulness of Germany, it is still true "that the school of all schools which has most influence on scientific teaching in America" was held in an old barn on an uninhabited island some eighteen miles from the shore. It lasted for three months, and in effect it had but one teacher. The school at Penikese existed in the personal presence of Agassiz; when he died, it vanished.

Contact with great minds is not so common to-day as it was when the men of the old school were the leaders of the new. The enthusiasm of struggle, the flash of originality, grows more rare as our educational machinery becomes more perfect. If our present system fails, it is in the lack of personal contact and personal inspiration. If we can not create new Darwins, the raw material being found, it is because they can not walk with Henslow. Henslow is somewhere else, perchance in some government bureau of science, or if he is present he has too much on his mind to be a good walker. We do not value him enough to make him free.

We have too much university in America, and too much of what we have in a boy's school. The university as such is a minor affair, an exotic attachment. Should a great teacher, a real man of God, of the god of things as they are, arise in the faculty, he becomes a department executive. More than half his students are of gymnasium grade, and nine tenths of his teaching is done by young men, men who have not made their mark or who have made it only as cog wheels in the machine. Too often these are caught in the grind and are never able to show what they might have been if their struggles had been towards higher ends. Smith teaching zoology 10; Brown, botany 7, and Robinson, geology 3, can not

lead their students or themselves to look on nature in the large or to see the wonderful vistas beheld by a Lyell or a Humboldt. The university in America is smothered by the college. The college has lost its refinement of purpose through coalition with the university. The two are telescoped together to the disadvantage of both. The boy has the freedom and the facility of the university when he can make no use of it. The university man is entangled in the meshes of the college. University facilities we have enough for ten times—twenty times—the number of students. We go into the market to hire young men to avail themselves of them. There is no corresponding emphasis laid upon men, and men of the first rank are no more numerous to-day than they were in the days of Agassiz, Lowell, Longfellow, Gray, Holmes, Dana, Silliman, Gibbs, Leidy, Goodwin, Angell, White and Goldwin Smith. It is the man who makes the school, and who completes the chain of heredity from the masters of the last century in Europe to the masters of the twentieth century in America. Excellent as our facilities are, complete as are our libraries, our laboratories and our apparatus, easy as is our access to all this, we have only made a beginning. Another ten years will see it all doubled. What we have is far from complete. But the pity of it is, our students will not guess its incompleteness. Half as much or ten times as much, it is the same to them as the doubling of the bill of fare at the Waldorf-Astoria would be unnoticed by the guests. A still greater pity is this, even the teachers will not know the difference. They can use only what they have time and strength for. The output is no greater for the helps we give. The greatest teacher is one who is ruler even over his books, and who is not smothered by them.

Enthusiasm is cultivated by singleness of purpose, and in our system we make provisions to distract rather than to intensify. There is a learned society, to which many of us belong, Sigma Xi. Its value depends on its ability to make good its motto, Spoudon Xynones, "Comrades in Zeal." We whistle to keep up our courage in the multitude, not of dangers, but of distractions, and if we whistle in unison we may keep step together. This society in a cooperative way, the same spirit in different places, stands for enthusiasm in science. Now enthusiasm comes from struggle, from the continuous effort to do what you want to do, and for the most part in the way you want to do it. Hence, comradeship in zeal should make for individuality, for originality.

The most serious indictment of the new school in science is its lack of originality. Even its novelties are not original. They are old fabrications worked over, with a touch of oddity in the working. The requirements for the doctor's degree tend to curb originality. But these do not go far. A man may be original and even in a dress coat in the daytime may be rated as *summa cum laude*. The greatest foe of originality is timeliness. Rather, timeliness is evidence of lack of originality, of lack of individual enthusiasm.

When a discovery is made in botany, the young botanists are drawn to it as herons to a search light, as moths to a lantern. In Dr. Coulter's words, "they all dabble in the same pool." Not long since the pool was located in morphology; then it was in embryology; then in the fields of mutative variations; now it is filled with unit characters and pedigreed cultures.

I would not underrate any of these lines of work, nor any other, but I respect a man the less when I see him leaving his

own field to plunge into one which is merely timely, into one in which discovery seems to be easy, and the outlook to a career to be facilitated.

All honor to the man who holds to his first love in science, whatever that may be, and who records his gains unflinchingly, though not another man on earth may notice what he is doing. Sooner or later the world of science returns to every piece of honest work. The revival of the forgotten experiments of the priest Mendel will illustrate this in passing. Hundreds of men are Mendelians now, who would never have thought of planting a pea or breeding a guinea pig had not Mendel given the clue to problems connected with these things.

The man of to-day, busied with many cares, looms up smaller than the man of the old school who walked with Henslow and then walked with nature. In this thought, it is easy to depreciate our educational present.

Homer, referring to the Greeks of earlier times, assures us, "There are no such men in our degenerate days." I have never verified this quotation—the men of our days are too busy to verify anything—but we may take the sentiment as characteristic. From the days of Homer till our own time, the man of the old school has always found the times out of joint. Perhaps, in getting so elaborately ready, we are preparing for a still more brilliant future. It may be that books, apparatus, material, administration and training are all worth their weight in men, and that modern educational opportunities are as much better than old ones as on the surface they seem to be. I know that all these misgivings of mine represent no final failure. Each generation has such doubts, and doubts which extend in every direction. The new strength of the new genera-

tion solves its own problems. The new men of the new schools of science will master the problems of abundance and of distraction even as ours solved the problem of hostility and of neglect. The man is superior to the environment, and the man of science will do the work he loves for the love of it. In this love he will develop the abundance of life in others as in himself, and this is the highest end of all our striving.

The atmosphere of a great teacher raises lesser men to his standard. It perpetuates the breed. It was not books nor apparatus that made Döllinger or Agassiz or Brooks successively centers, each of a school of research. It was the contagion of devotion, the joy of getting at the heart of things, the love of nature, the love of truth. Sometimes, in our wealth of educational opportunity, we long for the time when, as of old, the student had the master all to himself, the master unperplexed by duties of administration not called hither and thither by the duties of his station, but giving himself, his enthusiasm, his zeal and his individuality, to the student, not teaching books, but how to make books our servants, all this time master and student struggling together to make both ends meet and sometimes succeeding, "so happy and so poor." So it was in the old time, and so it shall be again when the new demands and the new wealth find their adjustment. And to find this we shall not go back to Grigsby's Station, nor yet to Penikese; for the scholars that are to be shall rebuild the American universities in their own way, as the scholars of to-day are restoring the University of Cambridge, and in a greater or less degree all other universities in all other lands where men know and love the truth.

DAVID STARR JORDAN

AN EXPERIMENT IN MEDICAL PEDAGOGY¹

You may be surprised to know that I am very thoroughly aware of a certain measure of unpopularity I possess as a teacher of pathology. The condition long ago acquired definite features of chronicity. I know too that a certain apprehension in some instances has been the chief impelling force for the thorough work students have done with me. It may also surprise you to learn that the realization of these conditions has never been especially pleasing.

In view of my considerable tenure of office in this institution, now eighteen years, it would seem as though some explanation for this state of affairs was about due and I have been impressed with the notion that an attempt to make one might at least entertain you for the period usually allotted to this part of the program. I prefer that you decide whether the explanation I am about to undertake of this unpopularity is an apology or a defense.

There is no doubt that some of this opprobrium which in common with most teachers has been my portion is due to curiosity of mine as to the facts possessed by students in regard to matters pathological and their ability to use them, a curiosity so overwhelming as to consume most of the time in the courses assigned me and to leave but little for the imparting of new or additional information. To ascertain the student's equipment with knowledge which has a real dynamic value and represents power rather than learning in the usual sense has always been a fascinating inquiry for me. To illustrate this some recent experiences using museum preparations for teaching purposes will serve. We have used such preparations in a routine way for a number of years in the patho-

¹ An address before the class graduating at the end of the winter quarter, 1910.